Background paper

Draft (5) : July 1984

Andrew Barnett

Rural Energy Technology Assessment and Innovation

Over ten years and many millions of dollars have now been spent in seeking solutions to the energy problems of rural areas of developing countries. But despite this effort, and the undoubted advances that have been achieved, many of the simplest questions posed by policy makers still cannot be answered. One such set of questions concerns the choice of energy conversion devices suitable for rural areas: it is not yet possible to provide anything but the broadest advice about which technical options are most suited for a particular purpose and location. The aim of this research is to address this set of issues concerned with meeting policy makers' requirements concerning the selection, development and introduction of such devices.

From a position of almost total ignorance in 1970, patchy evidence is now available about energy use and supply in a relatively small sample of rural communities; and the methods for such research are much improved (see Desai 1982; Howes 1983). But by comparison more is now known about the physical characteristics of conversion devices for use in rural areas. Much of the evidence on a number of these devices was brought together in 1983 and 1984 in a series of state-of-the-art reviews. Perhaps best known were the five technologies reviewed by the World Bank; but other studies are now appearing as part of exercises commissioned by IDRC/UNU (through their Energy Research Group) and SIDA. These reviews are generally regarded as being significantly better than anything which had appeared before. But despite the competence of each report, as a group they serve to illustrate the major limitations of knowledge:

- the lack of comparative evaluations of the various technologies under field conditions, using similar assumptions and within a single analytic framework;
- the under-emphasis of an understanding of the needs of the potential users of the technology and the consequences of low levels of "effective demand";
- the weakness of the financial, economic and other social science analyses of the technology choice (relative to the physical and engineering aspects);
- and, possibly with more justificiation in such a relatively new field, lack of knowledge about the mechanisms for the commercialisation and other forms of diffusion of the technology.

The reports also provide stark evidence of the complexity of the task facing policy makers. This arises from the wide range of end-uses and technologies involved, and the significant differences in their scale, sophistication, type of output produced (including not only heat and motive power but also public health and environmental benefits) and in their relative maturity.

Furthermore, the reviews (particularly those of the World Bank and SIDA) illustrate another feature of the field: they focus almost exclusively on so-called new and renewable technologies; however from a policy maker's point of view, the essential interest is how such technologies compare with each other and with other more conventional technologies, such as diesel, kerosene, petrol and electric motors, mini hydro, steam engines and even (small scale) ethanol plants. It is generally agreed that at least until very recently no appropriate data on the operation under rural conditions even of these "conventional" devices was available to form the base line comparison for new and renewable sources.

Successful attempts have been made to build a concensus between practitioners about the issues to be considered and the means of measuring the physical characteristics of a range of 'non-conventional' devices operating in the field. Most notably this has been achieved with photovoltaics, woodstoves, windmills and biogas plants. But there has been little attempt so far to generate such a consensus on the issues and means of measuring the social and economic consequences. In many cases the best analyses which have been undertaken, for instance in the World Bank reviews, incorporate a straightforward analysis of the financial costs of the various systems that are able to achieve a particular output (such as pumping a given amount of water through a particular head). The rather more difficult questions about the value of the output, or even the "real" resource costs of obtaining and operating the devices have rarely been addressed successfully.

Such a concentration on questions of whether the devices worked was clearly right in the early years of any programme. And knowledge of the physical characeristics of a system, its environment and the financial 'cost-effectiveness' of similar systems will remain a crucial step in any choice. But experience in other areas of rural technical change suggest that rational policies and effective programmes of implementation require consideration of a number of other issues.

It will be a central component of the research to elaborate these issues and to establish a concensus about the relevant research methods. But three issues may be considered by way of illustration. First, it is clear with hindsight that the failure of a particular attempt to change technology in either the modern or traditional sector can often be attributed to a failure to understand the demand side of the problem and in particular the end users' needs. Such needs are often difficult to determine in advance and are very poorly understood in relation to rural fuel systems. But, however complex the task, the assessment of the needs and 'effective' demand of rural people must be the starting point of any programme of change; in the modern sector this would constitute the market survey. The lack of authoritative 'market surveys' is alleged to be the main constraint to the diffusion of a number of energy technologies.

Among the few certainties about the rural energy problem is that the main requirement for fuel is currently for cooking; this is a highly complex set of tasks that are intimately linked to the sexual division of labour, culture and the domestic economy and therefore highly variable between peoples. It is also known that although very small amounts of inanimate energy (other than sunlight) are currently involved in rural production, major increases in productivity will be associated with massive increases in such sources of energy (for fertilizer, for irrigation, for mechanisation and for transport). The evaluation of the various options in both household and productive uses has to be conducted in relation to a highly specified set of end-uses, despite the obvious difficulty that such specification poses in practice.

Second, many of the transactions associated with the provision and use of existing rural fuels do not enter into the cash economy. This is particularly so in a very large proportion of the world's rural households where fuelwood and crop residues are collected by the ultimate user and not purchased. This lack of even the broadest guidelines to the value of commodities and activities provided by the market mechanism presents a formidable challenge to the researcher trying to estimate the benefits and burdens of particular competing devices in the fuel economy. This feature also distinguishes research in this area from the work of market survey. The value of labour time spent in collecting fuel, the value of woodfuel or the value of dung in its alternative uses of fertilizer and combustible fuel have proven particularly sensitive in determining the relative value of energy systems. In addition, the lack of cash in the domestic fuel system severely limits the commercialisation of new devices; the cash required to purchase the new device is not offset with cash savings however efficient the device may be; in such cases other, often difficult, forms of diffusion will have to be designed and implemented. Indeed, there appears to be a trend currently for projects to focus on the commercial diffusion processes to the relative neglect of the poverty related rural energy problems.

Thirdly, and on a very different plane, even if the relative merit of particular devices could be determined with sufficient certainty, the policy makers might more properly base their choice on <u>dynamic</u> considerations of how the technologies and operating environments might change over time. This is most often cited in the case of photovoltaic systems where major cost reducing technical breakthroughs are widely predicted and in relation to operation environments in which the real cost of oil will rise substantially. However, <u>all</u> rural energy conversion devices have a potential for technical change and the direction and speed of such change is to some extent a function of policy within individual or groups of countries. Similarly certain aspects of the operating environment (such as the price of agricultural commodities) is also subject to policy. Such dynamic considerations massively increase the complexity and scope of policy in the choice of technology.

Many developing countries can now be said to have completed the first phase of two largely separate lines of research: namely, rural energy demand surveys and the initial laboratory and field testing of rural energy devices. It is now widely perceived that the next phase is one of

monitoring existing energy technology programmes in the field, and bringing this experience together on a comparative basis to form a sound foundation for an effective programme of implementation. Such conclusions are most clearly expressed by the World Bank reviewers and within USAID, but similar views are also being put forward by a number of developing country governments and researchers. But initial reversals in attempts to introduce technologies such as photovoltaics, improved woodstoves and biogas serve to underline the importance of understanding the energy needs of rural people and the related non-technical factors such as the nature of rural societies and their interaction with the current and future fuel cycles, and the institutional realities of rural technical change.

Although the complexity of rural energy technology choice may seem formidable, a number of initial attempts to develop a suitable comparative analytical framework (most notably by Ramesh Bhatia and de Lucia, but see also French 1980, Santerre and Smith 1982, Barnett et al 1982) suggest that many of the elements of such a system exist; for instance, in the literature and practice of social cost benefit analysis, technology assessment and farm systems planning. The problem is therefore seen as more a problem of satisfying what policy makers need to know in order to choose, develop and implement relevant technology; and to develop a concensus among researchers and other practitioners as to what the key issues are and where they are not already known, determine how they might be researched in such a way as to best provide comparable results.

The initial problem can be conceived as one of evaluating the current state of the knowledge involved in considering rural energy technology options. While in practice there may be much controversy about the accuracy, level of detail and range of participants required to make decisions about technology, the chain of reasoning required is in principle fairly straight forward. In some form or another the process starts by consideration of what is known about the energy problems facing specific social groups; it considers what options there are for meeting these problems both now and in the future; it appraises the relative merit of the options from the point of view of the various parties both directly and indirectly involved and considers what needs to be done to effectively plan, implement, evaluate (and subsequently modify) the chosen option at local and other levels. At each point the costs and relative merit of obtaining more knowledge has to be weighed against the chances and consquences of delay and inappropriate decisions.

It is an hypothesis of this project that the necessary knowledge is available at many points along this chain; but that the strength of the whole chain is currently weakened by specific missing links. The strongest links appear to involve knowledge of the physical nature of the environment and energy conversion technologies; the weakest links involve the identification of user needs, the comparative evaluation of devices, social and economic analyses in general and the mechanisms to affect technical change.

The Research Network

The IDRC proposes to provide financial and other support to researchers in developing countries wishing to work on the comparative evaluation and innovation of energy conversion technologies which are suitable for rural application.

The proposed research forms a continuation of IDRC's commitment to support policy research in the energy sector. While stressing the importance of science and engineering, the programme has sought to avoid the pitfalls assoeciated with the development of hardware independently of the needs of users and the context of its use. Support has financed both rural energy surveys and rural energy technology assessment. The current project seeks to understand what can be concluded from this and other earlier work and to advance this understanding by authoriative research and by building the necessary research capacity.

The objectives, methods and institutional arrangements for the proposed research will be chosen by a group of researchers at a Project Identification Meeting to be held in Ottawa from 30 October to 1 November 1984.

In order to structure this meeting a number of possible options are described below:

I A Comparative Network versus an Association of Researchers

The research might be expected to have greatest impact on policy makers and other researchers if a similar activity is carried out simultaneously by a group of credible researchers in a range of countries. Participants in such a network could exchange knowledge and compare experiences in order to upgrade the quality of each team's research.

Such networks are themselves perhaps at their most effective when they have similar objectives, use a research method that is agreed in advance and is designed to compare situations both within and between countries.

But it must be recognised that such an ideal is difficult and expensive to achieve. It is to be expected, for instance, that at any one time countries have different research needs, and research methods that are possible in one place are impossible elsewhere. In some countries research on these issues is already well advanced; in others even the most preliminary knowledge or research capability is lacking.

The Project Identification Meeting should see to what extent such inter-country comparisions and the use of common objectives, definitions, assumptions and research methods are possible. If necessary, various compromises from this ideal could be considered; these would include the option (at the other end of the spectrum) of a series of studies being undertaken in each country and leaving the decision whether to meet and discuss results until the research is well under way.

II Types of research

Two broad types of research are envisaged: research that consolidates existing knowledge and research that generates entirely new knowledge predominantly from primary data collection in the field. While such a distinction is not unambiguous, consolidating research can be started quickly, can be carried by individuals and small teams, and is relatively inexpensive. Primary data collection by contrast usually requires a long lead time for design, site selection, recruitment and execution, and tends to be relatively expensive. In most cases this second type of research cannot be properly undertaken without the first type.

(a) Consolidation

It has been suggested earlier that a useful and necessary entry point to this research is the consolidation of the knowledge required to formulate and implement policies towards rural energy technology. In some countries the necessary knowledge is well established and the primary research needed to fill in the gaps is clearly identified. But it is a premis of this research that in most countries this is not the case. Here energy problems and the needs of the potential users of new technology are not well understood; research is well advanced on some technologies while others are neglected without reason.

It is therefore expected that a number of teams will wish to undertake research which clarifies what is known (both inside and outside their country) and what still needs to be researched. This will involve surveys of literature, local opinions (for instance the opinions of researchers, technology suppliers, policy makers) and the assembly and re-analysis of data already collected for other purposes.

A 'consolidating' research strategy does not necessarily imply delaying action nor should the proposed chain of reasoning behind technology choice be perceived as a 'maximalist approach' of an ideal world. Research can clearly take place alongside action; some actions are so obvious as to require no preliminary research; and the chain of reasoning should rather be considered as the minimum knowledge required to formulate and execute action.

Research topics that might be included under the heading of consolidation might include:

(i) the elaboration of the minimum knowledge required to make choices about rural energy technology;

(ii) the compilation and critical review of the current state of knowledge both inside and outside the country on:

- the energy use and supply situation in rural areas and their likely change over time; what surveys have been completed, how valuable are they; how general are their conclusions;

- the need and effective demand for energy related technical change by specific sections of the rural population;

- the range of both technical and non technical options for meeting the identified need;

- the comparative evaluation of the technical and non-technical options.

(iii) review and analysis of energy technology field testing sites (their location, size, range of technologies included, types of social, economic and technical date collected);

(iv) review and analysis of attempts to monitor the introduction of energy related technical change. A useful distinction may be made here between attempts to introduce technical change within the monetized parts of the energy sector where there is 'effective demand' and technical change in the non-monetized sector, where poverty and a delicate ecological balance reduce the room for manoeuvre;

(v) review and analysis of energy related research and development (resource allocation, range of research activities, range of technologies, resource allocation criteria, research output, research effectiveness);

(vi) review and analysis of the structure of the decision making process in the various stages of rural energy technology formulation and implementation in both the public and private sectors. Special emphasis might be placed on the research needs of the policy makers so identified.

(b) Primary Research

It is expected that some research teams already have identified the most pressing needs for research and that original primary data will need to be generated. Such research might include:

(i) gap filling rural energy use and supply surveys;

(ii) "need" and/or "market" assessments for particular devices or for particular end-uses;

(iii) the development and implementation of techniques to simplify market and need assessment surveys;

(iv) social, technical and economic analyses of new or existing field testing and demonstration programmes which attempt to evaluate energy conversion devices on a comparative basis;

(v) the addition of particular devices to existing field test sites to increase the range of comparison;

(vi) setting up and monitoring attempts at innovation through commercial and/or public mechanisms;

(vii) the design and implementation of studies to examine the range and effectiveness of rural energy R&D, and procedures for the search and selection of imported technology;

(viii) studies to assess the effectiveness of local and foreign consulting firms in the planning and execution of rural energy policy.

It should be stressed that it is clearly not expected that any research team will research all the issues listed. Indeed some researchers may only be able to cover one topic at a time and focus entirely on research consolidation.

III Network Participants

It is expected that the core of the network will be between 3-5 teams working full time on research funded at least in part by IDRC. However, some teams who are already well established in programmes of related research or have access to local funds, may wish to contribute their experience to the research network even though their reseach is not financed by IDRC.

Where it is not possible to identify teams, individuals may be contracted to research specific topics, but researchers who can work full time will be preferred.

Similarly some countries may not be able to recruit experienced researchers and the possibility will be considered of taking more junior researchers into the network and providing them with closer support, training and supervision than would normally be required.

While the network will be essentially involved with the technological aspects of rural energy and will doubtless involve many engineers and scientists, the network is concerned primarily with policy research and is therefore likely to incorporate the approach and techniques of social science (particularly of finance, economics and sociology).

IV Training

The project identification meeting will also have to decide whether specific forms of training are necessary to successfully undertake the research. At one level this might include providing short courses for the researchers to familiarise themselves with literature and/or techniques that are necessary for the research. At another level some form of group training might be necessary to help generate a concensus among the researchers on the objectives and research methods of the comparative elements of the network.

V Output

The main output of the network will be authoritative research results in written form. Th research is expected to have immediate practical application and particular attention will be given to ensure the quality and relevance of the results.

Each research team will initially report the results of their own work; consideration will then be given to the production of comparative or synthetic analyses covering particular themes tailored to particular types of audience.

The research results will be discussed at the national and international level in meetings with the relevant policy makers and researchers.

The network is also likely to increase the skill and experience of the participating researchers both as a result of direct training but also through contact with the other members of the network.

VI Co-ordination

The possibility exists for the network to be supported by a co-ordination team. The precise role of co-ordination will be determined in discussion with the researchers. Possible tasks include:

(i) administration of the network, circulation of work in progress, organising training programmes and work in progress discussions;

(ii) in response to requests from researchers, provide intellectual input to the research designs and methods and provide critical comments on work in progress;

(iii) find, review and where necessary provide relevant books and articles to the reseachers;

(iv) as required, provide synthesis and other reports on the research.